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ट्राँसफार्मरों और रिएकटर ध्वनि स्तरों के मापन की पद्धतियां

Indian Standard

METHODS OF MEASUREMENT OF TRANSFORMER AND REACTOR SOUND LEVELS

UDC 621·314·21 + 621·318·43·534·61

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BUREAU OF INDIAN STANDARDS
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Transformers Sectional Committee, ET 16

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Transformers Sectional Committee had been approved by the Electrotechnical Division Council.

In reporting the results of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

In the preparation of this standard, assistance has been derived from IEC Pub 551 (1976) 'Measurement of transformer and reactor sound levels' issued by the International Electrotechnical Commission.

Indian Standard

METHODS OF MEASUREMENT OF TRANSFORMER AND REACTOR SOUND LEVELS

1 SCOPE

1.1 This standard defines the methods by which the sound levels of transformers, reactors and their associated cooling plant shall be measured in the manufacturer's works so that compliance with any specification requirements may be confirmed and the characteristics of the noise emitted in service determined.

1.2 This standard is intended to apply to measurements made in the manufacturer's works as, when measurements are made on site, conditions may be very different due to proximity of other objects, extraneous noises, etc. Nevertheless, the same general rules as given herein may be followed when site measurements are made.

1.3 In those cases where sufficient power is available in the factory to permit full energisation of reactors, the methods to be followed are in same as for transformers. Such measurements shall be by agreement between the manufacturer and the purchaser. Alternatively, measurements may be made on site where conditions are suitable.

1.4 The methods defined are applicable to transformers and reactors of all types covered by IS 2026 (Part 1) : 1977 and IS 5553 series respectively without further limitation as regards size or voltage and when fitted with their normal auxiliary equipment, in as much as it may influence the measurement result.

1.5 Although the following test refers only to transformers, it is equally applicable to reactors provided that it is recognised that current taken by a reactor is dependent on the voltage applied and, consequently, that a reactor cannot be tested at no-load.

1.6 This standard gives a basis of calculation of sound power level which permits comparison of transformers of different types and, with certain hypothetical assumptions, the evaluation of the probable sound level at a distance. In view of this for the purpose of measurement of noise level of transformers/reactors only sound pressure level shall be measured.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
2026 (Part 1) : 1977	Power transformers : Part 1 General (*first revision*)
5553 series :	Reactors
9779 : 1981	Sound level meters

3 TERMINOLOGY

3.1 For the purpose of this standard, the following definitions shall apply.

3.2 Sound Pressure Level

The reading given by a sound level meter complying with IS 9779 : 1981.

3.3 Sound Power Level

The sound power level is equal to $10 \log_{10} P/P_0$ dB where P is the sound power, in watts, and P_0 is the reference sound power of 10^{-12} W.

3.4 Principal Radiating Surface

A hypothetical surface surrounding the transformer or cooling equipment which is assumed to be the surface from which sound is radiated. (The method for determining the principal radiating surface for particular equipment is given in **6.2**).

3.5 Prescribed Contour

A horizontal line, spaced at a definite distance from the principal radiating surface, along which the measurement points are located. (The method for determining the prescribed contour for particular equipment is given in **6.2**).

3.6 Effective Surface

A hypothetical surface on which measurements are assumed to have been made and which is used to calculate the sound power radiated by the equipment.

3.7 Background Noise

The noise picked up at the measuring points with the exclusion of that produced by the equipment the sound level of which is being measured. It includes the noise from all other apparatus necessary for the measurement process.

4 CONDITIONS FOR MEASUREMENT

4.1 Criteria for Adequacy of the Test Environment

Ideally, the test environment should be free from reflecting objects other than a reflecting floor so that the equipment under test radiates into a free field over a reflecting plane.

Test environments that are suitable for measurements according to this standard are those which meet the qualification procedures of Annex A.

4.2 Operating conditions of equipment during measurement for measurements made on the transformer with or without its auxiliary cooling plant, the transformer shall be on no-load and excited at rated voltage of sinusoidal or practically sinusoidal waveform and rated frequency with the tap-changer (if any) on the principal tapping. The voltage shall be measured according to **8.5** of IS 2026 (Part 1) : 1977.

If the transformer is fitted with reactor-type on-load tap-change equipment and the reactor may, on certain tap-change positions, be permanently energized, the measurements shall be made with the transformer on a tapping which involves this condition and as near as possible to the principal tapping. The excitation shall be appropriate to the tapping in use.

NOTE — It is assumed that where tap-changing is referred to in this subclause, the method of voltage variation will be such as to maintain constant flux in the core. For other methods of voltage variation, the tapping chosen and the excitation voltage shall be the subject of agreement between the manufacturer and the purchaser.

4.3 Quantities to be Measured

Transformer/reactor and background noise level shall be determined as a weighted surface sound pressure level *L*pA or correct mean sound level on the dB(A) weighting. To avoid measurement errors due to disturbing influences, the fast response indication of the meter shall be used.

5 INSTRUMENTS

Measurements shall be made using a sound level meter. The operating instructions given by the manufacturer of the sound level equipment should always be followed in order that the greatest degree of precision is achieved. In particular, instructions concerning the minimum proximity of the observer to the microphone, necessary to avoid errors arising from reflections, shall be met. An acoustic check of the measuring equipment using a calibrated noise source is to be made immediately before and after the measurement sequence.

6 MEASUREMENT METHODS

6.1 Measurement of Sound Pressure Levels

Background noise levels shall be measured immediately before and after the measurements on the equipment. If the background noise level is clearly very much lower than the combined level of the equipment and background [difference not less than 9 dB(A)], measurement of background noise need be made only at one of the measuring positions and no correction of the measured sound level of the equipment is necessary.

If the background level is such that the difference, in dB(A), between the mean combined level of the equipment plus the background and the mean background alone is less than 9 dB(A) the corrections shown in Table 1 shall be applied. In such cases, the background level shall be determined at every measuring position where the total number of measuring positions is 10 or less and at not less than 10 positions reasonably evenly distributed round the equipment when the total number of measuring positions exceeds 10.

If the difference is less than 3 dB(A) the test will not be accepted unless the combined level of the background and transformer or reactor noise is less than the guaranteed value. In such case, lower values for this difference will be accepted, but the test report shall record this condition and the determined value as the upper limit of the sound power level of the equipment.

The height(s) of the microphone(s) during the background measurements shall be the same as for measurement of the noise from the equipment and the background measurements shall be taken at points on the prescribed contour(s).

Table 1 Correction Factors for the Sound Level Measurements

(*Clause* 6.1)

Difference, in dB(A) Between the Mean Combined Level of the Equipment Plus the Background and the Mean Back-Background	dB(A) to be Subtracted from the Mean Combined Level of the Equipment Plus the Background (Factor *Y*)
3	3
4-5	2
6-8	1

Although the difference between the background noise level and that resulting from the combination of the equipment and background levels may be small, every effort should be made to obtain a difference at least equal to 7 dB(A) and if possible, to 9 dB(A) but should it be necessary to apply the correction of 3 dB(A), the corrected level is to be indicated (on the report) in inverted commas.

The mean levels (equipment plus background or background alone) shall be taken as the arithmetic average of all readings obtained on the equipment unless the difference between the extreme measured values is equal to or greater than 5 dB(A), when the quadratic mean value shall be used (*see* **7.1**) and Annex B.

6.2 Transformer/Reactor Sound Pressure Level Measurement

The following methods of equipment sound level measurement cover the different types of cooling employed depending on whether the radiators are less than or more than 3 m away from the principal radiating surface. They also permit the sound power level of the complete equipment and the sound level at a distance from the equipment to be calculated by the methods detailed in **7.3** and **7.4** respectively:

a) *Transformers having no forced air cooling auxiliaries or with forced air cooling auxiliaries mounted on a separate structure spaced not less than 3 m away from the principal radiating surface of the main tank*

Measurements on the transformer only are to be made in accordance with this subclause; those on any forced air cooling auxiliaries in accordance with **6.2** (c) below. The principal radiating surface is the surface obtained by the vertical projection from the top of the transformer tank cover (excluding bushings, turrets and other projections above the tank cover, *see* Fig. 1) to the base of the tank, of a string contour encircling the apparatus. The principal radiating surface shall include cooling equipment attached to the tank, tank stiffeners and such auxiliary equipment as cable boxes, tap-changer, etc, and exclude any forced air cooing auxiliaries. Projections such as bushings, oil pipework, oil conservators, tank underbase, valves and other secondary elements shall also be excluded.

The prescribed contour shall be spaced 0·3 m away from the principal radiating surface as defined above. For transformers with a tank height less than 2·5 m the prescribed contour shall be on a horizontal plane at half the tank height. For transformers with a tank height equal to or greater than 2·5 m, two prescribed contours shall be used which are on horizontal planes at one-third and two-thirds of the tank height.

Because of the distance between the prescribed contour and the forced air cooling auxiliaries, no account need be taken of the proximity of such auxiliaries when arranging the measuring positions. Any oil circulating pumps and forced air cooling equipment shall be out of service during the measurements on the transformer.

The measuring positions shall be at approximately equally spaced intervals not more than 1 m apart with a minimum number of six (*see* Fig. 1).

b) *Transformers having forced air cooling auxiliaries either mounted directly on the tank or on a separate structure spaced less than 3 m awav from the principal radiating surface of the main tank*

Two sets of measurements shall be made, both with the transformer energized:

1) with the forced air cooling equipment and any oil circulating pumps out of service; and

2) with the forced air cooling equipment and any oil circulating pumps in service.

The principal radiating surface is the surface obtained by the vertical projection from the top of the transformer tank cover (excluding bushings, turrets and other projections above the tank cover, *see* Fig. 1) to the base of the tank, of a string contour encircling the apparatus. The principal radiating surface shall include the forced air cooling auxiliaries, tank stiffeners and such auxiliary equipment as cable boxes, tap-changer, etc. Projections such as bushings, oil pipework, oil conservators, tank or cooler underbases, valves, control cubicles and other secondary elements, shall be excluded.

For the purpose of measurements (1) the prescribed contour shall be spaced 0·3 m away from the principal radiating surface. For the purpose of measurements (2) the prescribed contour shall be spaced 2 m away from the principal radiating surface.

For transformers with a tank height less than 2·5 m the prescribed contour shall be on a horizontal plane at half the tank height. For transformers with a tank height equal to or greater than 2·5 m, two prescribed contours shall be used which are on horizontal planes at one-third and two-thirds of the tank height.

The measurement positions shall be at approximately equally spaced intervals not more than 1 m apart, with a minimum number of 10 (*see* Fig. 2).

NOTE — Where the transformer is designed and intended for enclosure and the cooler, external to the enclosure; is spaced less than 3 m away from the transformer, then the procedure given in **6.2** (a) and **6.2** (c) shall be followed.

c) *Force air cooling auxiliaries or water cooling equipment mounted on a separate structure spaced not less than 3 m away from the principal radiating surface of the transformer/reactor*

These measurements are in addition to those made on the main equipment. They shall be made with the transformer unenergised and with all forced air cooling equipment and oil circulating pumps in operation. The measurements shall be regarded as additional requirements, unless otherwise specified, since it is often not the practice to erect separate cooling equipment except when temperature-rise tests are being made on the main equipment.

The principal radiating surface is the surface obtained by the vertical projection from the top of the cooler structure to the base of the active parts (*see* Fig. 3) of a string contour encircling the apparatus but excluding oil conservators, framework, pipework, valves and other secondary elements. The prescribed contour shall be spaced 2 m away from the principal radiating surface as defined above. The cooler structures with an overall height less than 4 m (excluding oil conservators, pipework, etc) the prescribed contour shall be on a horizontal plane at half the height. For cooler structures with an overall height (excluding oil conservators, pipework, etc) equal to or greater than 4 m, two prescribed contours shall be used which are on horizontal planes at one-third and two-thirds of the height. The measuring positions shall be at approximately equally spaced intervals not more than 1 m apart, with a minimum number of 10 (*see* Fig. 3).

d) *For dry type transformers and reactors*

It is under consideration.

7 CALCULATIONS AND INTERPRETATION OF RESULTS

7.1 Calculations of Corrected Mean Sound Level

A mean value $L_p(A)$ shall be calculated from the measured values of the A-weighted sound level $L_p(A)$ by using the following equation:

$$L_{p(A)} = 10 \log_{10} 1/N \left\{ \sum_{i=1}^{i=N} 10^{0.1 L_{pi(A)}} \right\} - X - Y - Z \quad \ldots (1)$$

where

$L_p(A)$ = quadratic mean sound level A (that is. A-weighted surface sound level) in decibels—Reference 20 μPa;

$L_{pi}(A)$ = A-weighted sound level from i^{th} measurement, in decibles — Reference 20 μPa;

N = total number of measurements;

X = correction for microphone constant;

Y = correction for background level according to **6.1**; and

Z = environmental correction to account for the influence of reflected sound.

The environmental correction Z typically ranges from 0 dB to more than 10 dB in highly reverberant rooms. However, for the purpose of this standard, the maximum allowable value of the environmental correction Z is 7 dB.

The procedures of Annex A are used to calculate the value of the environmental correction Z.

NOTE — When the range of values of $L_{pi(A)}$ does not exceed 5 dB a simple arithmetic average may be used as an acceptable approximation to the quadratic mean. This average will not differ by more than 0·7 dB from the value calculated using equation (1).

7.2 Calculation of the Area of the Effective Surface

a) Measurements on transformers energized and forced air cooled auxiliaries unenergised, as indicated in **6.2** (a) and (b) (1), made at 0·3 m away from the principal radiating surface. The area S of the effective surface, expressed in square metres, is calculated by the formula:

$$S = 1{\cdot}25\, h p_m \quad \ldots \quad (2)$$

where

h = height of the transformer tank, and

p_m = length of the prescribed contour.

1·25 is an empirical factor intended to take account of the sound energy radiated by the upper part of the transformer or coolers.

b) Measurements on transformers energized with forced air cooling auxiliaries also energised, as indicated in **6.2** (b) (2) also on forced air cooling auxiliaries mounted separately from the transformer, as indicated in **6.2** (c) made at 2 m away from the principal radiating surface. The area S of the effective surface, expressed in square metres, is calculated by the formula:

$$S = \frac{3}{4\pi} P_m^2 \quad \ldots (3)$$

where

P_m = length of the prescribed contour

$3/4\pi$ is an empirical factor derived from the equivalent hemisphere of the coolers plus the transformer, taking account of the combined sound energy radiated.

7.3 Calculation of A-Weighted Sound Power Level

To derive the A-weighted sound power level $L_W(A)$ from the measured equipment sound level, the following formula is used:

$$L_W(A) = L_p(A) = 10 \log_{10} S \quad \ldots (4)$$

where

$L_W(A)$ = weighted sound power level, in decibels, with respect to 10^{-12}W;

$L_p(A)$ = mean level, in dB (A) of measured sound levels; and

S = area of the effective surface (*see* **7.2**) expressed in square metres.

7.4 Calculation of Sound Level at a Distance from the Equipment

If the sound radiation of the equipment is assumed to be uniform in all directions, the equipment can be represented as a source of spherical waves as far as its distant sound level is concerned. With this assumption, the weighted sound power level of the equipment may be calculated from the measured equipment sound level (*see* **6.2**) and from this:

a) the sound level at a distance may be derived;

b) comparisons may be made between equipment of similar electrical characteristics but of different design or construction.

The sound level L_R at a distance R ($R >$ about 30 m) from the geometrical centre of the equipment is calculated from:

$$L_R = L_{W(A)} - 10 \log_{10} S_h \qquad \dots (5)$$

where

L_R = sound level in dB(A) and

$S_h = 2\pi R^2$ = area of the surface of a hemisphere of radius R m.

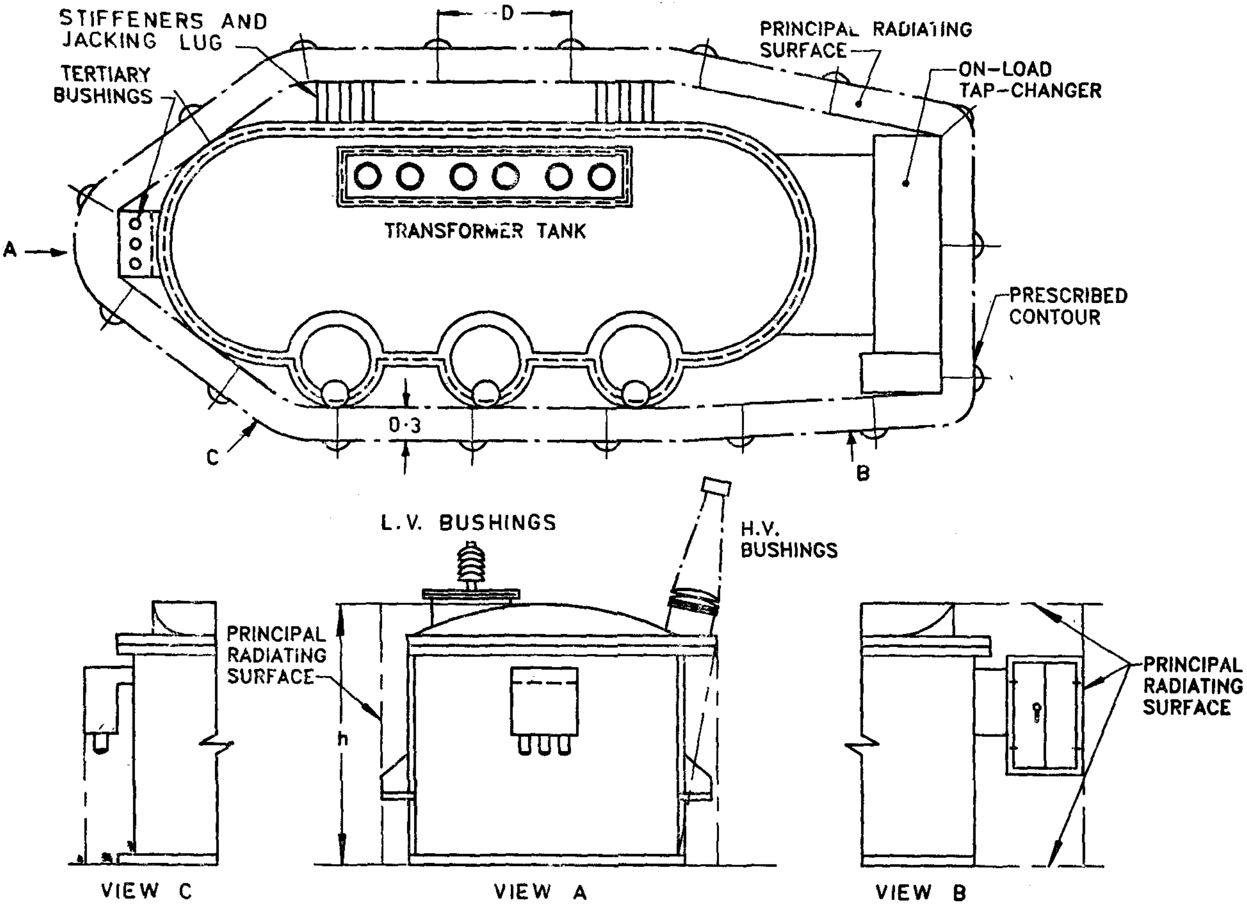
If there are two sources of sound power such as a transformer and its separate cooling auxiliaries, the individual weighted sound power level of such source should first be derived using equation (4). Equation (5) can then be applied to find the sound level of each source (considered independently) at the distant point under consideration and the two sound levels combined as shown in Annex B.

7.5 Application of the Calculation of Sound Level at a Distance to Specific Arrangements

a) If the sound level measurements are conducted with the transformer energised and any forced air cooling auxiliaries unenergised, as indicated in **6.2** (a) and **6.2** (b) (1). S is calculated from equation (2) (**7.2** a) and $L_{p(A)}$ is the mean value of all dB(A) sound level measurements made under these conditions.

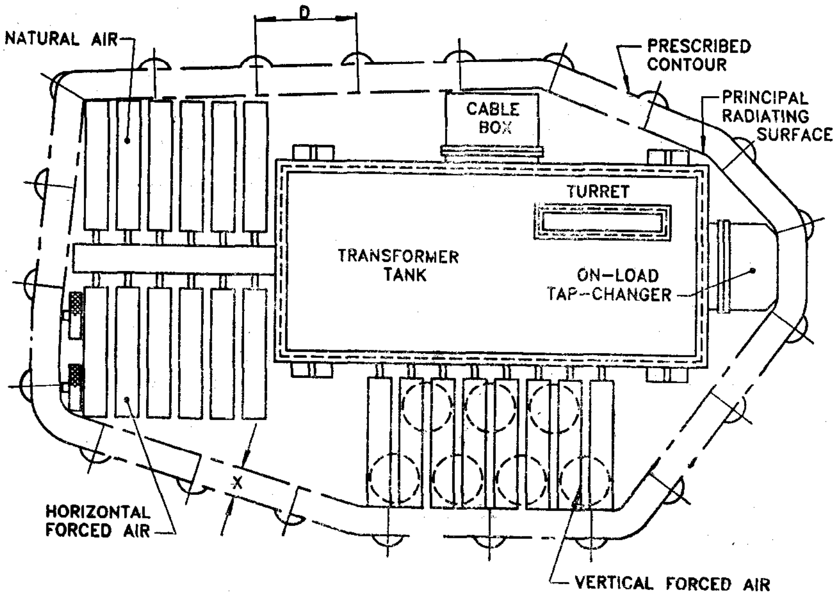
b) If the sound level measurements are conducted with the transformer energised and any forced air cooling auxiliaries also energised, as indicated in **6.2** (b) (2) or on the forced cooling auxiliaries alone when these are mounted at a distance greater than 3 m away from the transformer, as defined in **6.2**(c), S is calculated from equation (3) (**7.2** b) and $L_{p(A)}$ is the mean value of all dB(A) sound level measurements made under these conditions.

c) To determine the combined sound level of a transformer measured in accordance with **6.2** (a) and its forced air cooling auxiliaries measured in accordance with **6.2** (c) the method indicated in **7.4** for two sound sources shall be followed.



NOTE — D = Not to exceed 1 m.

FIG. 1 TYPICAL MICROPHONE POSITIONS FOR NOISE MEASUREMENT ON TRANSFORMERS EXCLUDING COOLING EQUIPMENT

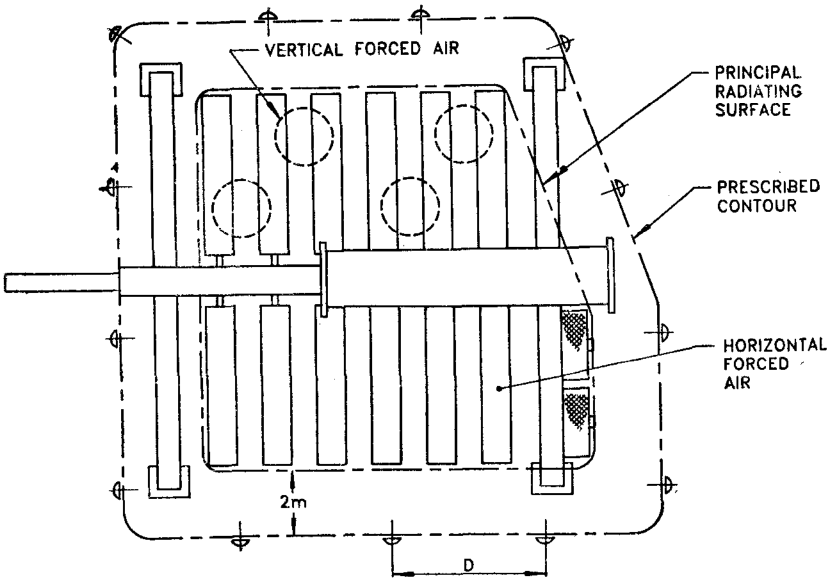


NOTES

1 Distance X is 0·3 m or 2 m, *see* 6.2 (b).

2 *D* = Not to exceed 1 m.

FIG. 2 TYPICAL MICROPHONE POSITIONS FOR NOISE MEASUREMENT ON TRANSFORMERS HAVING FORCED AIR COOLING AUXILIARIES EITHER MOUNTED DIRECTLY ON THE TANK OR ON A SEPARATE STRUCTURE SPACED LESS THAN 3 m AWAY FROM THE PRINCIPAL RADIATING SURFACE OF THE TRANSFORMER TANK



NOTE — *D* = Not to exceed 1 m.

FIG. 3 TYPICAL MICROPHONE POSITIONS FOR NOISE MEASUREMENT ON FORCED AIR COOLING AUXILIARIES MOUNTED ON A SEPARATE STRUCTURE SPACED NOT LESS THAN 3 m AWAY FROM THE PRINCIPAL RADIATING SURFACE OF THE TRANSFORMER TANK

8 PRESENTATION OF RESULTS

The report shall include such of the following information as is applicable to the equipment of which the sound level has been measured:

a) Reference to the measurement specification.

b) A description of the transformer giving rated power, voltage and voltage ratio, connections, etc.

c) The name of the transformer maker and the place of manufacture.

d) Details of instrument and method of verification of its acoustical calibration. This information shall include the serial numbers of the instrument, of the microphones and of the calibration source.

e) A dimensioned sketch showing the position of the transformer with respect to other objects in the measurement area and the measuring positions.

f) The results of the sound level measurements at each measuring point.

g) The results of background level measurements and the relevant points of measurements.

h) The mean values of sound level for the following operating conditions:

  1) transformer fully equipped with its auxiliaries out of service
  2) transformer fully equipped with its auxiliaries in service
  3) cooling equipment in service with transformer energised.

j) The mean values of background measurement for (1), (2) or (3) above corrected for background, microphone constant and environmental conditions.

k) The area of the effective surface for measurements at 0·3 m away from the principal radiating surface.

m) The area of the effective surface for measurements at 2 m away from the principal radiating surface.

n) The A-weighted sound power level(s) for the operating conditions (h) (1), (h) (2) and (h) (3) above.

NOTE — A typical form for presentation of results is given in Annex C.

ANNEX A

(*Clauses* 4.1 *and* 7.1)

TEST ENVIRONMENT QUALIFICATION PROCEDURE

A-1 GENERAL

An environment providing an approximately free field over a reflecting plane shall be used for measurements made according to this standard. The environment may be provided in an ordinary test room if the requirements given in this Annex are satisfied.

Reflecting objects should be removed to the maximum extent possible from the vicinity of the equipment under test with the exception of the reflecting plane. A test room should ideally provide prescribed contours which lie:

a) inside a sound field essentially undisturbed by reflections from nearby objects and the room boundaries, and

b) outside the near field of the sound source under test.

For the purposes of this standard, the prescribed contour is considered to lie outside the near field if the measurement distance from the source under test is equal to or greater than 0·3 m.

A-2 ENVIRONMENTAL CONDITIONS

A-2.1 Properties of Reflecting Plane

For indoor measurements, the reflecting plane is usually the floor of the room.

NOTE — When the reflecting surface is not a ground plane or the floor of the test room, care shall be taken to ensure that the reflecting surface does not radiate any appreciable sound energy due to vibrations.

A-2.1.1 *Shape and Size*

The reflecting surface shall be larger than the area enclosed by the projection of the prescribed contour on the plane.

A-2.1.2 *Sound Absorption Coefficient*

The sound absorption coefficient of the plane shall be less than 0·1 over the frequency range of interest. Wooden and tile floors are permitted.

A-2.2 Reflecting Objects

No reflecting objects that are not part of the source under test shall be located inside the projection of the prescribed contour.

A-3 QUALIFICATION PROCEDURE AN REQUIREMENTS FOR TEST ROOMS

A-3.1 Test Procedures

The environmental correction Z in equation (1) of 7.1 accounts for the influence of undesired sound reflections from room boundaries and/or reflecting objects near the source under test. The magnitude of this environmental correction Z depends principally on the ratio of the sound absorption of the test room A to the area of the effective surface S. The magnitude does not depend much on the location of the source in the test room.

In this standard, the environmental correction Z is obtained from Fig. 4 by entering the abscissa with the appropriate value of A/S.

The area S of the effective surface is calculated from equation (2) or (3) given in **7.2**.

Two alternative methods are given to determine the total sound absorption A of the test room.

A-3.1.1 *Estimate of the Sound Absorption A*

The mean sound absorption coefficient of the surfaces of the test room (walls, floor and ceiling) is estimated by using Table 2. The value of A is then calculated from:

$$A = aS_v \quad \ldots \quad (1A)$$

where

S_v = area of the surface of the test room, in square metres; and

a = mean sound absorption coefficient (*see* Table 2).

A-3.1.2 *Experimental Determination of the Sound Absorption A*

The sound absorption A may be determined by measuring the reverberation time of the test room, excited by broad-band noise, with A-weighting on the receiving system. The value of A is then:

$$A = 0{\cdot}16 \frac{V}{T} \quad \ldots \quad (2A)$$

where

V = volume of test room, in cubic metres; and

T = reverberation time of test room, in seconds.

A-4 QUALIFICATION REQUIREMENTS FOR TEST ROOMS

For the effective surface in a test room to be satisfactory for measurements according to the requirements of this standard in ratio A to S shall be equal to or greater than 1, that is

$$\frac{A}{S} \geqslant 1$$

If the above requirement cannot be satisfied, the ratio A/S may be increased by introducing additional sound absorbing materials into the test room and then redetermining the value of the ratio A/S under these new conditions.

If the requirements of this clause cannot be satisfied for any effective surface which lies outside the near field of the source under test, the particular environment cannot be used for measurements on the source under test according to the requirements of this standard.

Table 2 Approximate Values of the Mean Sound Absorption Coefficient of a Room

(*Clause* A-3.1.1)

Mean Sound Absorption Coefficient	Description of the Room
0·05	Nearly empty rooms with smooth hard walls made of concrete, brick, plaster or tile
0·1	Partly empty rooms, rooms with smooth walls
0·15	Rectangular machinery rooms, rectangular industrial rooms
0·2	Irregularly shaped machinery rooms or industrial rooms
0·25	Machinery or industrial rooms with a small amount of acoustical material on ceiling or walls (for example, partially absorbent ceiling)

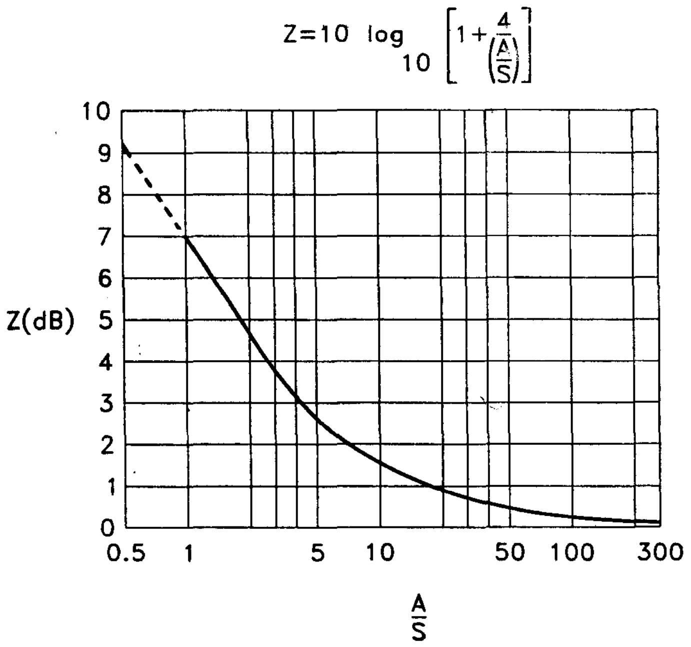


FIG. 4 ENVIRONMENTAL CORRECTION FACTOR Z, IN DECIBELS

ANNEX B

(*Clauses* 6.1 *and* 7.4)

CALCULATION OF QUADRATIC MEAN

Given two sound levels L_a and L_b, L_a being larger than or equal to L_b, the quantity $L_{(a,\,b)}$ is defined as:

$$L_{(a\ b)} = 10 \log_{10} (10^{0\cdot1 L_a} + 10^{0\cdot1 L}) \qquad \ldots \text{(1B)}$$

The curve below shows the evaluations of the quantity: $\triangle L = L_{(a\ b)} - L_a$ as a function of the difference of L_a and L_b. It permits the rapid evaluation of $L_{(a,\,b)}$ from L_a and L_b.

$$L_{(a,\,b)} = L_a + \triangle L \qquad \ldots \text{(2B)}$$

where

$\triangle L = 10 \log_{10} (1 + 10^{0\cdot1}\,_{x})$

$x = L_b - L_a$

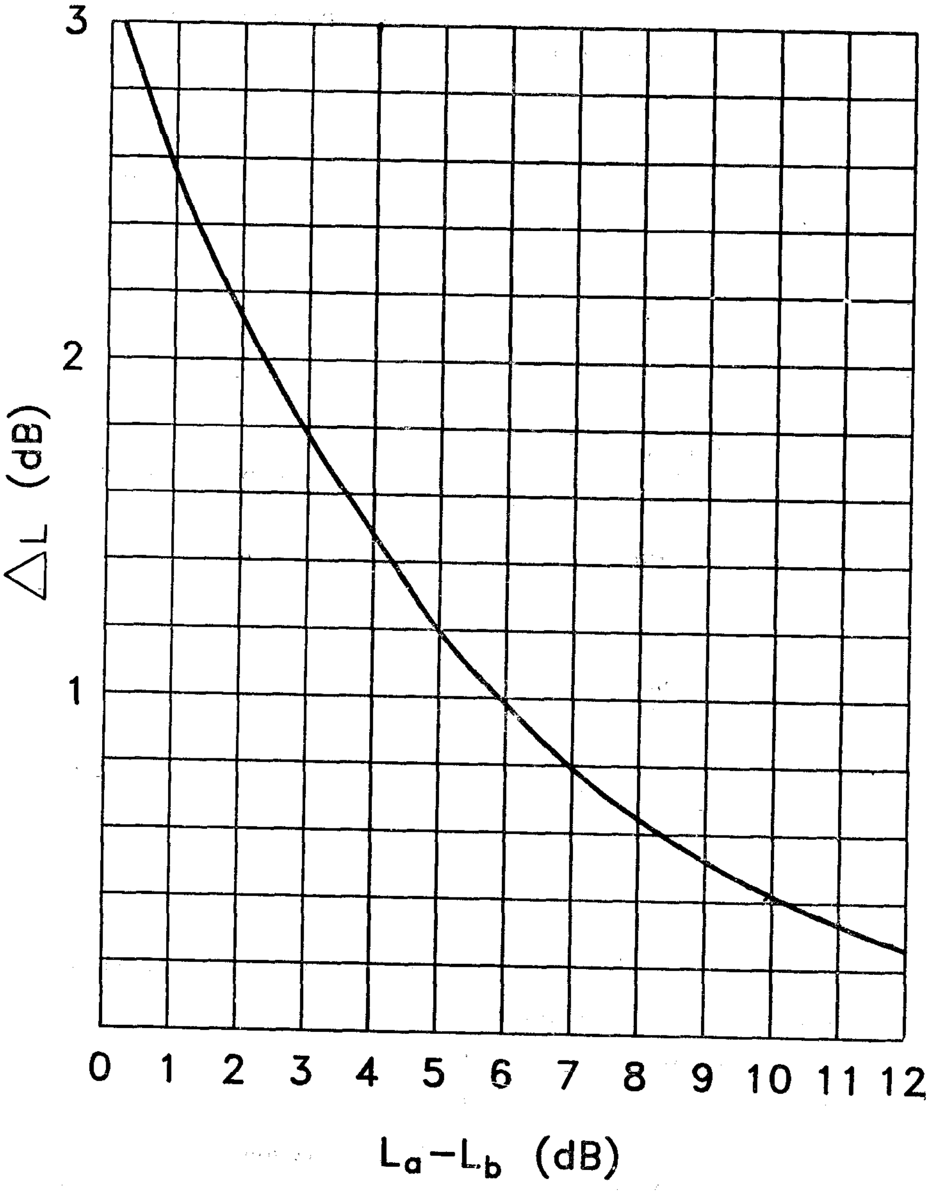


FIG. 5 CALCULATION OF QUADRATIC MEAN

In order to determine the quadratic mean $L_{p(A)}$ of n sound levels $L_{pi(A)}$ as referred to in **6.1**, the following quantities are successively calculated using the curve:

$L(1,2) = 10 \log_{10} (10^{0\cdot1} L_1 + 10^{0\cdot1} L_2)$

$L(1,2,3) = 10 \log_{10} [10^{0\cdot1} L_{(1,2)} + 10^{0\cdot1} L_3]$

$L(1,2,3 \ldots n) = 10 \log_{10} [10^{0\cdot1} L_{(1,2,3)} \ldots {}_{n-1} + 10^{0\cdot1} L_n]$

From this, the quardratic mean is determined:

$$L_{p(A)} = L(1,2,8 \ldots n) - 10 \log_{10} n \qquad \ldots \text{(3B)}$$

ANNEX C

[*Clause* 8 (*Note*)]

RECORD OF SOUND LEVEL MEASUREMENT

Contract number and site ____________________

Manufacturer __________ Place of measurement __________ Date of measurement __________

Place of manufacture __________ Measurement specification __________

Details of transformer:

Serial No. __________ MVA __________ Voltage radio __________ Connections __________

Tapping range ____________________

Details of measuring instrument:

Make __________ Type __________ Serial No. __________

Microphone type __________ Microphone serial No. __________

Calibration data of instrument and microphone ____________________

____

____

Test conditions:

Excitation voltage __________ Frequency __________ Hz Tap position __________

Sound level meter reading: Background noise levels	dB(A)									
Plan position										
At start of measurements										
At conclusion of measurements										
Mean (arithmetic/quadratic)										

Measured sound levels: *i)* Transformer without coolers
ii) Transformer with coolers
iii) Coolers without transformer
} *Delete as appropriate*

Plan position	dB(A)	Plan position	dB(A)	Plan position	dB(A)	Plan position	dB(A)
1		13		25		37	
2		14		26		38	
3		15		27		39	
4		16		28		40	
5		17		29		41	
6		18		30		42	
7		19		31		43	
8		20		32		44	
9		21		33		45	
10		22		34		46	
11		23		35		47	
12		24		36		48	
						Total	
						Mean of sound level meter readings (aritmetic/quadratic):	

Correction for microphone constant (if any) (X) = ☐

Correction for background level (Y) = ☐

Environmental correction (Z) = ☐

Total correction $X + Y + Z$ = ☐

Mean sound level (rounded in accordance with note) ☐

Area of effective surface:

a) for measurements as 0·3 m away from the principal radiating surface __________ m^2

b) for measurements at 2 m away from the principal radiating surface __________ m^2

A-weighted sound power level __________ dB

Note — The mean sound level and sound power level should be rounded to the nearest whole number, decimal values of 0·5 dB and above being rounded to the next higher whole number.

Plan of transformer, indicating measurement positions with respect to the H.V. bushings proximity of nearby sound reflecting surfaces, e.g. equipment, walls, etc, and positions of background noise level measurement.

Height of microphone(s) above ground____________________ and ____________________metres.

Remarks, additional results, etc (including details of any significantly high sound levels at positions other than the measurement positions):

Persons present during sound level measurements:

*Signed*____________________ *Date* ____________________

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